Pol. J. Environ. Stud. Vol. 33, No. 3 (2024), 3067-3078
DOI: *10.15244/pjoes/178324* ONLINE PUBLICATION DATE: 2024-03-28

Original Research

Adoption of Environment-Friendly Climate Smart Agricultural Practices and Prevailing Constraints: Policy Implications for Cotton Growers of Southern Punjab, Pakistan

Farhan Ullah Basharat[1], Ejaz Ashraf[1]*, Muhammad Luqman[1], Saima Sadaf[1], Salman Ahmad[2], Muhammad Younas Afzal[1], Ikram ul Haq[3], Usman Saleem[3]

[1]Department of Agricultural Extension & Rural Studies, College of Agriculture, University of Sargodha, Punjab-Pakistan
[2]Department of Plant Pathology, College of Agriculture, University of Sargodha, Punjab-Pakistan
[3]Department of Plant Breeding & Genetics, College of Agriculture, University of Sargodha, Punjab-Pakistan

Received: 29 September 2023
Accepted: 6 January 2024

Abstract

Presently, the agricultural system and crops related to the environment are highly vulnerable to climatic variations in many regions of the world. Major crops are under serious threat due to floods and temperature variations in Pakistan. There is a serious need to disseminate climate smart agricultural knowledge for the farmers of Pakistan at urgency level for fast adoption of Climate Smart Agricultural Practices (CSAPs). This study mainly focuses on the adoption of CSAPs and associated constraints, which restrain the adoption rate. We selected 400 cotton farmers using a formula suggested by Kesley and Kumar (1989) for an unknown population from two very important cotton producing districts (Khanewal and Vehari). Interview schedule was used for data collection. The study explored that institutional role is very critical for adoption of CSAPs. In addition, economic barriers, lack of trained extension field staff, lack of training opportunities and lack of climate smart agricultural technologies and knowledge for cotton growers are the main constraints in the adoption of CSAPs. Hence, awareness, provision of timely information and training, continuous repeated coordination with cotton growers and reducing all constraints are the keys for approval of CSAPs to deal with climate variations. Policy recommendations included: government should provide policy support for research and development activities focusing on CSAPs. Government should provide support to extension services in order to educate and train farmers for CSAPs. The adoption of CSAPs may require additional financial resources. The government should provide financial support to farmers to encourage them to adopt these practices. This can be done through subsidies, grants and other financial incentives. Climate change is leading to water scarcity in Pakistan and this is affecting agricultural productivity. The government should promote water conservation practices such as rain water harvesting, drip

*e-mail: ejaz.ashraf@uos.edu.pk

irrigation and water efficient crops to ensure sustainable use of water resources. The adoption of CSAPs requires strong collaboration and partnerships among the stakeholders, including government, farmers, research institutions, NGOs and private sector. The government should promote collaboration and partnerships to facilitate the adoption of CSAPs.

Keywords: climate smart agricultural practices, Punjab, Pakistan, cotton growers, institutional role

Introduction

The importance of sustainable agriculture is increasing with the growth of the agricultural industry, because it involves economic viability, social equity, an environmental health [1]. With the high increase in population and greater demand for food, land and natural resources, it is very much important for agriculture related industries to adapt and innovate without disturbing the quality of life for future generations [2]. The effects of climate change can be reduced through adoption of conservative practices. Diversified production systems offer opportunities to reduce irrigation demand in comparison to conventional farming systems [3, 4].

According to the Food and Agriculture Organization (FAO) of the United Nations, the world population of 6.8 billion people today is projected to increase to 9.1 billion people by 2050, which will require a greater demand for food, land, and other natural resources. As the world's largest industry, agriculture is dependent on natural resources, therefore it must also continue to adapt and innovate without jeopardizing stewardship of the land and quality of life for future generations [5]. On one hand, land use including deforestation accounts for 30% of the total global greenhouse gas emissions; while on the other hand, the adverse impacts of climate change are leading to land degradation, and food insecurity [6]. Similarly, more productive and supple agriculture requires administration of natural and environmental resources [7]. Transforming to such systems may generate significant benefits [8].

After wheat, cotton is the most significant and largest cash crop in Pakistan in terms of area. It adds 6.5% to agricultural value addition and 1% to the country's GDP overall. It is the primary source of raw materials for the textile industry and an important source of foreign exchange [9]. Despite being the fourth-largest producer of cotton in the world, Pakistan's cotton crop is sensitive to climate change and has seen several shocks over the years as a result of poor market performance, conventional agricultural management practices, and changing weather patterns. Pakistan's cotton crop is severely impacted by climate change as a result of heavy fertilizer and pesticide use, along with high irrigation water demand [10]. The majority of researchers discovered that climate change had a negative impact on Pakistan's cotton crop and climate change had a detrimental impact on Pakistan's cotton production [11]. Most of the researchers found that production of cotton in Pakistan is negatively affected by climate change and inefficient cotton production management practices. The increased vulnerability of cotton crop to insect and pest attacks, declining crop yields, excessive use of groundwater, deterioration of natural resources and human health due to chemical based conventional agriculture have raised concerns about the long-term sustainability of the system [12].

The FAO is advising a sustainable agricultural production system, or Climate-Smart Agriculture Practices (CSAPs), as an alternative to conventional agriculture in response to social, environmental, and economic issues brought on by climate change and conventional agriculture. CSAPs lower greenhouse gas emissions, boost agricultural productivity and resilience, and optimize the use of natural resources. CSAPs are methods or technologies that enhance farm income and productivity while reducing greenhouse gas emissions, improving resilience to climate change, and optimizing the use of water and nutrients [13]. The implementation of either singular or combined CSAPs and technologies can significantly mitigate the negative impact of climate variability on agriculture. Consequently, CSAPs adoption in cotton production can reduce the negative effects of climate change on the crop's production, while also increasing yield, farm income, and resource use efficiency [14]. CSAPs and technologies are thought to be able to support three pillars of CSAPs, i.e., lower greenhouse gas emissions, enhanced productivity, and climate change resilience. Multiple shocks, including market failures, climate change, and inadequate agricultural management practices, severely reduced cotton crop productivity [15]. The adoption rate of CSAPs is influenced by social and economic traits of the agricultural region, economic benefits to the farmers, farmers land holdings, role of agricultural research and educational institutes, extension services and government policies. The present study focuses on two core objectives: 1) adoption of CSAPs by the cotton growers of district Vehari and Khanewal, Punjab, Pakistan, and 2) associated constraints which restrain the adoption rate of CSAPs in the same districts.

Material and Methods

The descriptive correlational survey research methodology was applied to measure all research objectives related to factors involved in climatic variations and how they affect agricultural practices

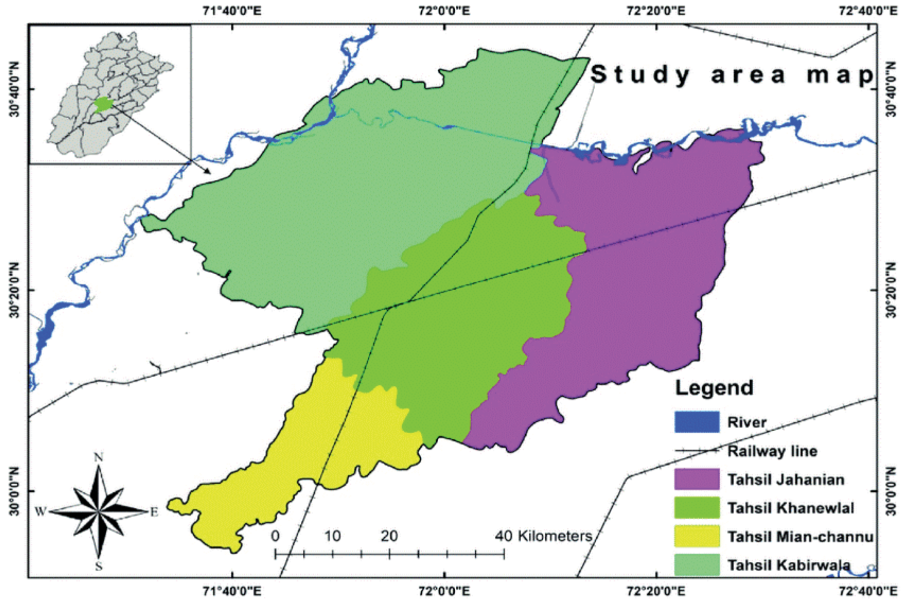

Fig. 1. The map of district Khanewal- Punjab, Pakistan.

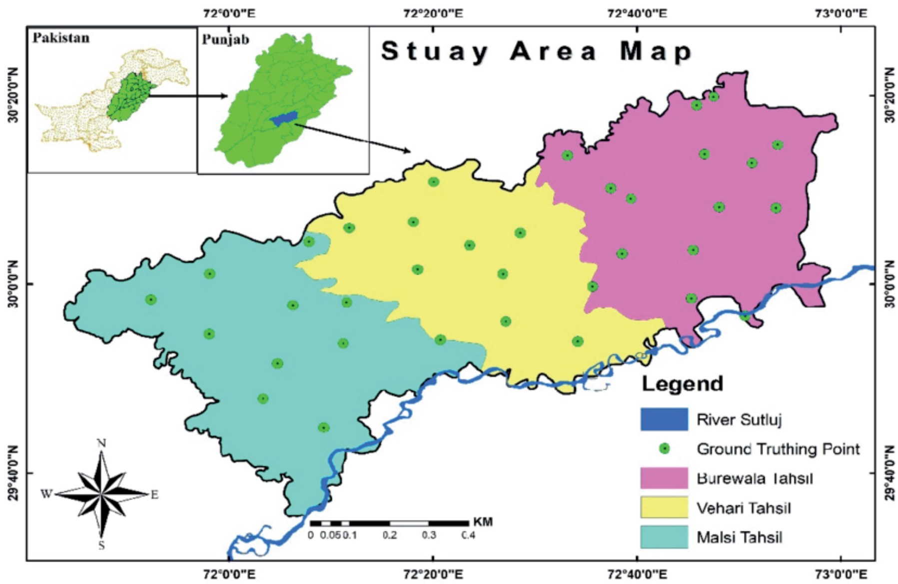

Fig. 2. The map of district Vehari-Punjab, Pakistan.

and attitudes of cotton growers towards technology adoption. The study was conducted in two purposively selected districts, i.e., Khanewal in Fig. 1 and Vehari in Fig. 2 of Punjab, Pakistan.

All cotton growers in these districts were considered as the population of the study and therefore considered as sampling frame. The population of the respondents from the selected smallest unit of the sampling frame was unknown, hence formula suggested by Kelsey and Kumar [16] for unknown population was applied to decide overall sample size which is as under:

$$n = \frac{Z^2 V^2}{d^2}$$

Where

Z = Reliability coefficient (Constant) = 1.96

V = 51% variation assumed in the responses of the selected cotton growers in the sample

d = assumed marginal error (5%)

Hence $$n = \frac{(1.96)^2 (0.51)^2}{(0.05)^2} = 399.68 \approx 400$$

The Multistage random sampling approach was used to select 400 respondents from the population of cotton growers in two study districts. The approach involved randomly selecting two tehsils, five union councils, two villages, and 20 cotton growers from each selected village.

Results and Discussion

Impact of Climate Variations on Cotton Growing Practices As Perceived By Cotton Growers

The study objective-1 was to measure the impact of climate variations on cotton growing practices as perceived by cotton growers in the study area. Thoughts of the respondents in the study area were measured and the results tabulated in the following Table 1.

Table 1 reveals that climate variations have a moderate impact on cotton growing practices in the study area as perceived by farmers. In particular, the impact of pest and disease management practices were ranked as high (mean score of 3.51 and ranked at 1) while weed management practices and changes in tillage practices showed a moderate impact (mean score of 3.11 and ranked at 4). In this context, it is further observed that post-harvest losses management with mean score of 3.03, management of premature ripening with mean score of 2.60, soil management practices with mean score of 2.62, and practices to manage losses due to high and low rainfall with mean score of 2.76 ranked at 7, 14, 13 and 12, respectively, reveal little to moderate impact of climate variation on respective practices of the growers.

Presently, agriculture is under threat across the world because of the constant climate change [17]. In this regard, CSAPs have become pivotal to address issues related to severe decline in agricultural productivity, and further to mitigate the effects of climate change [18]. In recent years, focus is being given to agriculture during world climate change discussions, since being the most significant cause of greenhouse gasses worldwide [19, 20]. Climate change is currently posing severe effects on agriculture, and will continue to pose in the near future also. CSAPs are playing a key role in combating these challenges, and are providing solutions enhancing agriculture productivity, ameliorating livelihood, and creating more robust agricultural systems [21-23]. The effects of climate change are rapidly increasing on crops productivity and farmer's livelihood in Pakistan with the passage of each day. Cotton is the main cash crop of Pakistan; but unfortunately to fulfill the domestic needs, it is now being imported from Egypt and some other countries [15, 24]. CSAPs are a ray of hope for the local cotton farmers of Punjab province to increase their cotton yield and in turn enhance their livelihood [15]. The main purpose of this study was to measure the impact of growers of the study area. The results indicate that climate variations have moderate impact on the cotton practices of the growers and if necessary measures would not be taken it may pose a serious threat to the future cotton crops in the region. These results confirm the previous findings [25-27]. In a recent study, it has been concluded that effects of climate variations are deepening every year in the cotton belt of Punjab, Pakistan. Climate variations reduce cotton yield by disturbing morpho-physiological and biochemical processes. Our study revealed that impact of climate variations was high on pest, disease and weed management practices in cotton growing districts [28]. This could be because climate variations are continuously causing mutations in pathogens, pests and weeds, and making them more resistant to pesticides and weedicides. This is resulting in less control of these pests, which in turn are drastically reducing

Table 1. Impact of climate variations on cotton growing practices.

Cotton growing practices	n	Mean	Std. Dev.	Rank
Disease management practices	400	3.51	1.08	1
Pest management practices	400	3.51	0.99	2
Soil fertility management practices	400	3.12	1.03	3
Changes in tillage practices	400	3.11	1.14	4
Weed management practices	400	3.11	1.25	4
Improved efforts to increase soil fertility	400	3.06	1.09	6
Postharvest losses management	400	3.03	1.13	7
Soil erosion management practices	400	3.01	1.04	8
Soil moisture management practices	400	2.98	0.96	9
Plant protection efforts and management practices	400	2.94	1.03	10
Practices to manage Postharvest losses	400	2.93	0.90	11
Practices to manage losses due to high and low rainfall	400	2.76	1.04	12
Practices of general soil management	400	2.62	1.03	13
Premature ripening management practices	400	2.60	1.09	14

Scale: No impact at all = 1, Little impact = 2, Moderate impact = 3, High impact = 4, Very high impact = 5 cotton yield and increasing input costs of the cotton farmers [29].

Importance of CSAPs as Perceived by Cotton Growers

The results of the study presented in Table 2 show the importance of CSAPs as perceived by the cotton farmers. The thoughts of the respondents according to the objective under study were measured and the results tabulated in the following Table 2.

Table 2 indicates that cotton growers perceive all CSAPs as moderately important. Laser land leveling (LLL) was ranked as the most important practice (mean score of 3.53 and ranked at 1), followed by the use of weather forecasts (mean score of 3.41 and ranked at 2), and prompt weeding (mean score of 3.36 and ranked at 3). The least important practices, according to respondents were the use of drones and computer based tractors (ranked at 16 and 17, respectively, with mean scores of 2.46 and 2.43) and zero or minimum tillage (ranked at 18 with a mean score of 2.42).

The results of the present study revealed that cotton growers recognize all CSAPs as moderately important. However, statistically LLL significantly ranked more important practice, along with the use of weather forecasts and prompt weeding. These findings confirm the previous studies [30-32]. The cotton yield can be significantly increased by adopting LLL, because it saves irrigation water and other input materials. In many parts of the world, LLL is being promoted as CSAPs for its eco-friendly benefits which include minimizing the risks of salinity and soil erosion, and ameliorating ground water level. Adoption of LLL in the cotton belt of Punjab can further be accelerated as CSAPs by the support of the provincial government, taking suggestions from input dealers and engaging progressive farmers of this region [33]. We also identified use of weather forecasts as the second significant CSAP for cotton growers in our study area. It has been reported from previous studies that meteorological services are of higher importance for the applications of inputs, and sowing and harvesting of cotton crops. Meteorological services have been improved using internet technology in different parts of the world which have increased precision of weather forecasts which have positively influenced cotton crop and farmers have attained higher yields [34]. In African countries, meteorological service systems have been established for cotton growers involving service institutions, transport, household and consumers, which enabled farmers to have good yields of their cotton crop. Weather stations that work

Table 2. Importance of CSAP as perceived by respondents.

Importance of CSAP	N	Mean	Std. Dev.	Rank
Laser land leveling	400	3.53	1.24	1
Use of weather forecasts	400	3.41	1.23	2
Prompt weeding	400	3.36	1.04	3
High efficiency irrigation	400	3.34	1.06	4
Genetically modified cotton	400	3.21	1.12	5
Use of water efficient cotton varieties	400	3.17	1.11	6
Improved irrigation system	400	3.12	0.99	7
Nutrient efficient varieties	400	3.09	1.22	8
Crop diversification	400	3.07	1.16	9
Crop rotation	400	3.07	1.21	9
Adoption of drought resistant varieties	400	3.05	1.08	11
Changes in sowing time	400	2.93	1.07	12
Integrated Pest Management	400	2.90	1.19	13
Use of shelter belts	400	2.84	1.13	14
Mulching	400	2.49	1.13	15
Use of drones	400	2.46	1.48	16
Use of computer based tractor (easy chair)	400	2.43	1.44	17
Zero or minimum tillage	400	2.42	1.03	18
Water harvesting	400	2.42	1.21	18

Scale: Not important at all = 1, little important = 2, moderately important = 3, highly important = 4, extremely important = 5 automatically could further improve the ability of weather predictions and could foretell well in advance to make correct decisions for cotton crop for employing inputs to ensure high yields [35, 36].

To Assess the Information and Training Sources Used by Growers for Adoption of CSAPs as Perceived by Cotton Growers

The study aimed to evaluate the information and training sources used by cotton growers in the study area for the adoption of CSAPs, as well as to identify the constraints faced by them in the adoption of such practices. The thoughts of the respondents in the study area were measured and the results tabulated in the following Table 3.

The Table 3 displays the results of the evaluation of various information and training sources used by the cotton growers. Fellow farmers, private companies, and farmers' corner meetings are being the most moderately used sources of the cotton growers in the study area. Fellow farmers with mean score of 3.47 at rank 1, private companies with mean score of 3.11 at rank 2 and farmers' corner meeting with mean score of 2.83 at rank 3 are the main information and training sources moderately used by the cotton growers.

In our findings, fellow farmers, private companies, and corner meetings were the moderately used sources of knowledge, information and training for the cotton growers in terms of CSAPs adoption in the study region. The climate smart agricultural knowledge transfer can improve the awareness of the respondents to deal with climate variation. The similar factor of knowledge production was discussed by Sultana [37] in her doctoral dissertation pointed out that there are multiple factors changing the knowledge co-production in Sindh province of Pakistan such as natural disasters, socio-economic shifts, political/power dynamics and water management. Our revelations are also aligned with Kuvelkar et al. [38] who found that farmers, meetings and private companies, field agents are the main source of information for the farmers of underdeveloped countries. There may be several reasons behind the significant role of private companies providing knowledge and training to the cotton farmers. The reasons may be that the private companies' representatives have more frequent visits to farmers, they organize on farm meetings with farmers almost on a weekly basis, and they offer incentives to farmers. Further, every company has its own separate research and development (R&D) program which conducts research on social, personal, psychological, ecological and economic factors of farmers. Therefore, farmers have more confidence in private companies for taking new knowledge about agricultural innovations [39, 40].

To Identify the Constraints Faced by Growers for Adoption of CSAPs As Perceived by Cotton Growers

Table 4 shows the constraints faced by cotton growers in adopting CSAPs. Economic barriers, lack of trained extension staff, lack of training and CSA technologies being the main constraints faced by them. Overall, respondents faced moderate levels of constraints in adopting CSAPs, and there is a need for

Table 3. Information and training sources used by growers for adoption of CSAPs.

Info. and training sources		Mean	Std. Dev.	Rank
Fellow farmers	400	3.47	1.12	1
Private companies	400	3.11	1.18	2
Farmer meetings	400	2.83	1.12	3
Electronic media (TV, Radio, Documentaries)	400	2.66	1.14	4
Print media	400	2.49	1.12	5
Social media	400	2.33	1.20	6
Internet	400	2.33	1.28	6
Non-government orgs.	400	2.31	1.15	8
Agricultural exhibitions	400	2.29	1.22	9
Yield days	400	2.24	1.12	10
Public Extension Dept.	400	2.24	1.15	10
Seminars	400	2.20	1.14	12
Demonstration plots	400	2.11	1.09	13
Field days	400	2.06	1.09	14

Scale: Rarely used = 1, used up-to some extent = 2, moderately used = 3, highly used = 4, always used = 5 intervention from concerned departments to address these constraints before they become a crisis for the respondents. The constraints faced by growers for adoption of CSAPs according to the thoughts of the respondents in the study area was measured and the results tabulated in the following Table 4.

Table 4 depicts a number of constraints faced by farmers in adoption of CSA practices. Generally, respondents face moderate levels of all constraints in adoption of CSAPs. However, economic barriers with mean score of 3.74 at rank 1, lack of trained extension staff with mean score of 3.65 at rank 2, lack of training with mean score of 3.64 at rank 3 and lack of CSA technologies with mean score of 3.62 at rank 4, and these constraints are approaches from moderate to high level cotton growers in adoption of CSAPs in the study area. There is a growing need that concerned departments have to intervene in the matter before it becomes a real crisis for the respondents.

These findings are in alignment with the previous research [41-43]. The study results showed that respondents considered little to moderate role of extension services organizations in fostering CSAPs in the region. According to the perceptions of the respondents, the approaches like farmer-to-farmer extension and farmer field schools have moderate role on behalf of the established institutions for fostering CSAPs among cotton growers of the region. Sultana [37] also emphasized on the role of Agricultural Extension services in disseminating knowledge to promote practical know-how of climate smart agriculture in Sindh province of Pakistan. The land managers in Punjab mainly relied upon extension services for agricultural innovation. Yigezu et al. [44] found that extension services significantly reduced time in adopting the technology of zero tillage in Syria. Extension services have augmented the adoption of CSAPs in India and many countries of the word [45]. Hence, the information received from informal and formal sources is vital for improving the knowledge of cotton farmers in the selected study area.

To Identify the Institutional Role in Fostering CSAPs Among Cotton Growers as Perceived by Respondents

The next research objective aimed at to determine how institutions contribute to fostering CSAPs among cotton growers according to the perceptions of respondents.

Institutional role in fostering CSAPs among cotton growers according to the thoughts and feelings of the respondents in the study area was measured and the results tabulated in the following Table 5. Table 5 summarizes the results of this assessment, where respondents were asked to rate the level of institutions for various initiatives related to CSAPs. The mean scores and ranks for each initiatives are also provided.

Following table measured the Institutional role in fostering CSAPs among cotton growers as perceived by respondents. Next, institutional role in fostering adoption of CSAPs among respondents was explored and measured in the perspectives of the opinion of the respondents.

The data presented in the above table shows the institutional role in fostering CSAPs among cotton growers. Generally, the respondents feel that institutions have little to moderate role with an overall mean score of 2.93 in fostering CSAPs among cotton growers in the study area.

However, respondents perceived moderate institutional role specifically for the "use of farmer-

Table 4. Constraints faced by growers for adoption of CSAP.

Constraints	n	Mean	Std. Dev.	Rank
Economic barriers	400	3.74	1.31	1
Lack of trained extension staff	400	3.65	1.22	2
Lack of training opportunities	400	3.64	1.16	3
Lack of CSA technology	400	3.62	1.14	4
Lack of support from government agencies	400	3.35	1.19	5
Lack of support from non-government agencies	400	3.28	1.12	6
Stereotype behavior of the respondents	400	3.27	1.12	7
Illiteracy	400	3.23	1.18	8
Lack of access to the latest information	400	3.14	1.10	9
Social barriers	400	3.12	1.13	10
Lack of access to electronic media	400	2.95	1.19	11
Lack of access to print media	400	2.82	1.18	12

Little constraint = 1, constraint up to some extent = 2, moderate constraint = 3, High constraint = 4, Very high constraint = 5

Table 5. Institutional role in fostering CSAPs among cotton growers as perceived by respondents.

Institutional role	n	Mean	Std. Dev.	Rank
Use of farmer-to-farmer extension method to promote awareness and adoption of precision technologies in climate smart agri. practices.	400	3.23	1.17	1
Use of farmer field school (FFS) to promote faster learning by farmers on the measures to tackle climate changes	400	3.19	1.23	2
Use of information communication technologies (ICTs).	400	3.06	1.15	3
Capacity building of extension staff in advanced agricultural technologies to deal climate variations	400	3.01	1.23	4
Use of law enforcement agencies against persons who deliberately indulge in practices that contribute to climate change	400	2.97	1.15	5
Use of farmer to farmer extension strategy for providing knowledge regarding advanced technologies to manage climate variations	400	2.97	1.24	5
Follow up visits of extension field staff	400	2.92	1.21	7
Denial of services to the farmers who indulge in practices that contribute to climate change	400	2.87	1.07	8
Providing feedback to governments and interested agencies	400	2.86	1.14	9
Subsidies on the material used for CSA practices	400	2.86	1.27	9
Use of demonstration method to teach farmers	400	2.76	1.19	11
Extension services regarding CSA practices	400	2.75	1.17	12
Continuous provision of knowledge regarding climate smart agricultural practices and climate variations	400	2.69	1.05	13

Scale: No role at all = 1, little role = 2, moderate role = 3, high role = 4, very high role = 5

to-farmer extension method to promote awareness and adoption of precision agricultural technologies in CSAPs with mean score of 3.23 at rank 1, "Use of farmer field school (FFS) to promote faster learning by farmers on the measures to tackle climate changes" with mean score of 3.19 at rank 2, "Use of information communication technologies (ICTs)" with mean score of 3.06 at rank 3 and "capacity building of extension staff in advanced agricultural technologies to deal with climate variations" with mean score of 3.01 at rank 4. The results of the measured objectives suggest that institutions need to focus on these specific initiatives to foster the adoption of CSAPs among cotton growers in the study area.

These results are in line with the previous findings [15], they reported moderate role of institutional factors in the adoption of CSAPs in the cotton belt of Punjab, Pakistan. Previously, it has been reported that farmer-to-farmer extension method has significant impact adopting precision agriculture practices in different parts of the world [46, 47]. Institutional factors allows farmers to decide whether or not to adopt at least one CSAPs measure [15, 46]. Likewise, FFS also play a significant role in convincing farmers towards CSAPs [48]. Several studies in the past have confirmed that FFS have played a vital role in shifting farmers towards environment resilient agriculture [49]. Since FFS approach complements the conventional technology transfer approach in providing information on best practices for agriculture, thus our findings bear equally significant implications in view of research, indicating that the key to optimizing the uptake of new agricultural interventions is agricultural information rather than the other factors [49].

Regression Model Used to See How Institutional Role, Information and Training, Constraints in Adoption and Importance of CSAPs Bring Change in the Overall Impact of Climate Variation on Cotton Growing Practices of the Growers

The study utilized a regression model to examine the impact of institutional role, information and training, constraints in adoption, and the importance of CSAPs on cotton growing practices in response to climate variation.

Table 6 presents the model summary, indicating that the independent variables explained 36.7% of the variation in the dependent variable. However, 64% of the variation remains unexplained suggesting that there is considerable variation in the responses of the survey participants.

Table 7 presents the ANOVA, showing that there is a significant difference between the groups with a p-value 0.000 indicating that H_o should be rejected. The table further displays that mean square values, F-value, and degrees of freedom, demonstrating that the difference between groups is not due

Table 6. Model Summary.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.606	0.367	0.361	6.43068

Predictors: (Constant), Institutional role, Information & training, constraints in adoption of CSAP, Importance of CSAP
b. Dependent Variable: Impact of climate variation on cotton practices

Table 7. Analysis of variance (ANOVA).

Model		Sum of Squares	Df	Mean Square	F	Sig.
	Regression	9478.999	4	2369.750	57.304	0.000
	Residual	16334.698	395	41.354		
	Total	25813.698	399			

a. Dependent Variable: Impact of climate variation on cotton practices
b. Predictors: (Constant), Institutional role, Information & training, constraints in adoption of CSAP, Importance of CSAP

Table 8. Coefficients.

Model		Un-standardized Coefficients		Standardized Coefficients	t	Sig.
		Beta	Std. Error	Beta		
	(Constant)	18.100	1.950		9.283	0.000
	Importance of CSAP	0.301	0.029	0.507	10.465	0.000
	Info & training	-0 .001	0.041	-0 .001	-0.030	0.976
	Constraints in adoption	0.163	0.041	0.185	4.007	0.000
	Institutional role	0.018	0.034	0.024	0.524	0.600

Dependent Variable: Impact of climate variation on cotton practices
Every one unit change in importance of CSAP brings the 0.507 beta coefficient level change in the impact of climate variation on cotton growing practices of the respondents

to chance.

Table 8 provides information on the un-standardized and standardized Beta coefficients of the independent variables. The table shows that the importance of CSAPs has the most significant effect with a beta coefficient of 0.507 in impacting the climatic variations on cotton practices. Conversely, institutional role did not have very high effect with an insignificant p-value and small beta coefficient. The independent factor of constraints in adoption had good effect with a significant p-value and beta coefficient. However, information and training had negative effect as the beta coefficient value was negative (-0.001). Hence the findings depict that as per opinion of the respondents "importance of CSAPs" and "reducing constraints in adoption of environment friendly CSAPs" are major contributors in bringing change in CSAPs of cotton farmers in the study area.

Computation of Effect Size

To assess the practical effect of the perception variable of Vehari and Khanewal districts, Cohen's effect size was computed. According to Cohen, a d value of 0.2 is considered small effect size, 0.5 represents medium effect size, and 0.8 a large effect size. This involves that if the means of two groups differ by 0.2 or less, then the difference is trivial, even statistically significant [50].

Cohen's d $= (M_{Khanewal} - M_{Vehari})/SD_{pooled}$ *Where* $SD_{pooled} = \sqrt{(SD_1^2 + SD_2^2)/2}$
Hence the Effect Size *Cohen's d* $= (24.05-22.84)/4.94 = 0.24$

$Mean_{Khanewal} = 67.215$ $Mean_{Vehari} = 66.950$
Hence the Effect Size Cohen's
$d = (67.215-66.950)/11.447 = 0.023$

Cohen's d value is calculated by subtracting the means of the two groups and then dividing by the pooled standard deviation. In the present study, the Cohen's d attitude towards CSAPs was found to be 0.24, which is a small effect size [50]. It shows that farmers of Khanewal district have a better attitude towards CSAPs by 24% of a standard deviation than respondents from

Vehari district. Similarly, the effect size for adoption of CSAP to deal with climate variation was also measured which was found to be 0.023. It means that respondents from Khanewal district have a very small effect size of 2.3% SD over farmers of Vehari district regarding adoption of CSAPs to deal with climatic variations. Hence, Cohen's effect size further confirms that there is no significant difference in the adoption level of CSAPs to deal with climatic variations of the respondents from the two districts.

It is witnessed from the regression model that importance of CSAPs and reducing constraints in adoption of environment-friendly CSAPs are the major contributors in bringing the change in the cotton growing practices of the respondents to tackle climate variations in the cotton region of the country. This is in line with the findings of [10, 15, 51, 52].

Conclusions and Recommendations

In conclusion, the study found that respondents in the study area understand the importance of CSAPs and are moderately impacted by climate variations in their cotton growing practices. However, there is a need to improve the institutional role in providing advanced research based information and training to farmers to bring about a change in their practices. Moreover, the study identified economic barriers, lack of trained extension field staff, training opportunities, and lack of climate smart agricultural technologies as the main constraints in the adoption of CSAPs. Therefore, it is important to address these constraints to facilitate the smooth adoption of CSAPs among cotton growers in the study area. It is also concluded from the regression analysis that the importance of CSAPs and reducing constraints in adoption are the solution to persuade the adoption of CSAPs among cotton growers in the study region.

Based on conclusions drawn from the study, following recommendations are proposed; policy makers should have a high level of understanding of the issue of climate variations and its potential impact on cotton growers in the region; government must frame desired climate related policies and take timely actions to hold the issue before it becomes crises for cotton growers in the region; awareness campaigns should be conducted to inform cotton growers about the importance of CSAPs; timely information and training should be provided to help them adopt these practices; continuous coordination and collaboration with cotton growers should be maintained to ensure that they have the necessary support to overcome the hurdles and constraints they face in adopting CSAPs; and the extension department should take an active role in educating and training cotton growers to help them become more proactive, vigilant and knowledgeable about CSA practices.

Acknowledgments

This manuscript is the part of doctoral degree research work of the first author Mr. Farhan Ullah Basharat. The author expresses his sincere thanks and gratitude to major supervisor Prof. Dr. Ejaz Ashraf and other members of the supervisory committee of the research study such as Dr, Muhammad Luqman, Dr. Saima Sadaf, Dr. Salman Ahmad, Dr. Ikramul Haq, Dr. Usman Saleem and fellow co-worker Mr. Muhammad Younas Afzal for their valuable suggestions to improve the quality of the research work. At the end, the first author acknowledges the participation of the respondents in this research since the study would have not been completed had they have not taken interest in this research.

Funding

This study has not been funded by any institution.

Conflict of Interest

All contributing authors have declared that there is no conflict of interest.

References

1. MITTAL S., MEHAR M. Socio-economic factors affecting adoption of modern information and communication technology by farmers in India: Analysis using multivariate probit model. The Journal of Agricultural Education and Extension. **22** (2), 199, **2016**.
2. EWERT F., BAATZ R., FINGER R. Agroecology for a Sustainable Agriculture and Food System: From Local Solutions to Large-Scale Adoption. Annual Review of Resource Economics. **15**, 351, **2023**.
3. DAVI J.E., NOGUEIRA B.K., GASQUES L.R., DALLA CÔRT A.S., CAMARGO T.A.D., PACHECO L.P., SILVA L.S., SOUZA E.D.D. Diversified production systems in sandy soils of the Brazilian Cerrado: Nutrient dynamics and soybean productivity. Journal of Plant Nutrition. **46** (8), 1650, **2023**.
4. MARTÍNEZ-VALDERRAMA J., OLCINA J., DELACÁMARA G., GUIRADO E., MAESTRE F. T. Complex Policy Mixes are needed to cope with Agricultural Water demands under Climate Change. Water Resources Management. **37** (6-7), 2805, **2023**.
5. BARATI A.A., AZADI H., MOVAHHED MOGHADDAM S., SCHEFFRAN J., DEHGHANI POUR M. Agricultural expansion and its impacts on climate change: evidence from Iran. Environment, Development and Sustainability. 1, **2023**.
6. XIAN C., GONG C., LU F., WU H., OUYANG Z. The evaluation of greenhouse gas emissions from sewage treatment with urbanization: Understanding the opportunities and challenges for climate change mitigation in China's low-carbon pilot city, Shenzhen. Science of the Total Environment. **855**, 158629, **2023**.

7. AZAM W., KHAN I., ALI S.A. Alternative energy and natural resources in determining environmental sustainability: a look at the role of government final consumption expenditures in France. Environmental Science and Pollution Research. **30** (1), 1949, **2023**.
8. GLIESSMAN S.R. Transforming food and agriculture systems with agroecology. Agriculture and Human Values. **37**, 547, **2020**.
9. SULTAN M., KHAN M., KHAN H., AHMAD B. Pathways to strengthening capabilities: A case for the adoption of climate-smart agriculture in Pakistan. APN Science Bulletin. **12** (1), 171, **2022**.
10. KHATRI-CHHETRI A., AGGARWAL P.K., JOSHI P.K., VYAS S. Farmers' prioritization of climate-smart agriculture (CSA) technologies. Agricultural systems. **151**, 184, **2017**.
11. ZULFIQAR F., THAPA G.B. Determinants and intensity of adoption of "better cotton" as an innovative cleaner production alternative. Journal of cleaner production. **172**, 3468, **2018**.
12. KHATRI-CHHETRI A., ARYAL J.P., SAPKOTA T.B., KHURANA R. Economic benefits of climate-smart agricultural practices to smallholder farmers in the Indo-Gangetic Plains of India. Current Science. 1251, **2016**.
13. ZULFIQAR F., DATTA A., THAPA G.B. Determinants and resource use efficiency of "better cotton": An innovative cleaner production alternative. Journal of cleaner production. **166**, 1372, **2017**.
14. ALI A., ERENSTEIN O. Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. Climate Risk Management. **16**, 183, **2017**.
15. IMRAN M.A., ALI A., ASHFAQ M., HASSAN S., CULAS R., MA C. Impact of Climate Smart Agriculture (CSA) practices on cotton production and livelihood of farmers in Punjab, Pakistan. Sustainability. **10** (6), 2101, **2018**.
16. KELSEY J.L. Risk factors for osteoporosis and associated fractures. Public Health Reports. **104** (Suppl), 14, **1989**.
17. ZHAO J., LIU D., HUANG R. A Review of Climate-Smart Agriculture: Recent Advancements, Challenges, and Future Directions. Sustainability. **15** (4), 3404, **2023**.
18. DORJI K., MILLER J., WU S. Agricultural Interventions in the Bhutanese Context for Sustainability – A Documentary Analysis Using a Thematic Conceptual Framework. Sustainability. **15** (5), 4177, **2023**.
19. HAMRANI A., AKBARZADEH A., MADRAMOOTOO C. A. Machine learning for predicting greenhouse gas emissions from agricultural soils. Science of The Total Environment. **741**, 140338, **2020**.
20. HOCKSTAD L., HANEL L. Inventory of US greenhouse gas emissions and sinks. Environmental System Science Data Infrastructure for a Virtual Ecosystem **2018**.
21. KHATRI-CHHETRI A., PANT A., AGGARWAL P.K., VASIREDDY V.V., YADAV A. Stakeholders prioritization of climate-smart agriculture interventions: Evaluation of a framework. Agricultural systems. **174**, 23, **2019**.
22. BOURSIANIS A.D., PAPADOPOULOU M.S., DIAMANTOULAKIS P., LIOPA-TSAKALIDI A., BAROUCHAS P., SALAHAS G., KARAGIANNIDIS G., WAN S., GOUDOS S. K. Internet of things (IoT) and agricultural unmanned aerial vehicles (UAVs) in smart farming: A comprehensive review. Internet of Things. **18**, 100187, **2022**.
23. ISLAM N., RASHID M.M., PASANDIDEH F., RAY B., MOORE S., KADEL R. A review of applications and communication technologies for internet of things (Iot) and unmanned aerial vehicle (uav) based sustainable smart farming. Sustainability. **13** (4), 1821, **2021**.
24. JAFFAR IQBAL M.F., ROMAN M., MAGSI S., RAUF H., ARIF Z., KHALIQ T., TAHIR M. 15. Climate change effects on cotton planting date and planting density using modelling techniques. Pure and Applied Biology (PAB). **12** (1), 732, **2023**.
25. RAHMAN M.H.U., AHMAD I., GHAFFAR A., HAIDER G., AHMAD A., AHMAD B., TARIQ M., NASIM W., RASUL G., FAHAD S. Climate resilient cotton production system: a case study in Pakistan. Cotton Production and Uses: Agronomy, Crop Protection, and Postharvest Technologies. 447, **2020**.
26. BANGE M. ., BAKER J.T., BAUER P.J., BROUGHTON K.J., CONSTABLE G.A., LUO Q., OOSTERHUIS D.M., OSANAI Y., PAYTON P., TISSUE D.T. Climate change and cotton production in modern farming systems. CABI, **2016**.
27. LI N., LI Y., BISWAS A., WANG J., DONG H., CHEN J., LIU C., FAN X. Impact of climate change and crop management on cotton phenology based on statistical analysis in the main-cotton-planting areas of China. Journal of Cleaner Production. **298**, 126750, **2021**.
28. ARSHAD A., RAZA M.A., ZHANG Y., ZHANG L., WANG X., AHMED M., HABIB-UR-REHMAN M. Impact of climate warming on cotton growth and yields in China and Pakistan: A regional perspective. Agriculture. **11** (2), 97, **2021**.
29. GUO Z., GUO L., BAI Y., KANG S., SUN D., QIN J., YE F., WANG S., WU Q., XIE W. Retrotransposon-mediated evolutionary rewiring of a pathogen response orchestrates a resistance phenotype in an insect host. Proceedings of the National Academy of Sciences. **120** (14), e2300439120, **2023**.
30. PAL B.D., KAPOOR S., SAROJ S., JAT M.L., KUMAR Y., ANANTHA K. Adoption of climate-smart agriculture technology in drought-prone area of India–implications on farmers' livelihoods. Journal of Agribusiness in Developing and Emerging Economies. **12** (5), 824, **2022**.
31. KAKRALIYA S.K., JAT H.S., SINGH I., GORA M., KAKRALIYA M., BIJARNIYA D., SHARMA P.C., JAT M.L. Energy and economic efficiency of climate-smart agriculture practices in a rice–wheat cropping system of India. Scientific Reports. **12** (1), 8731, **2022**.
32. ATSIAYA G.O., GIDO E. O., WALUSE SIBIKO K. Uptake of climate-smart agricultural practices among smallholder sorghum farmers in Busia County, Kenya. Cogent Food & Agriculture. **9** (1), 2204019, **2023**.
33. PAUDEL G.P., KHANAL A.R., KRUPNIK T.J., MCDONALD A.J. Smart precision agriculture but resource constrained farmers: Is service provision a potential solution? Farmer's willingness to pay for laser-land leveling services in Nepal. Smart Agricultural Technology. **3**, 100084, **2023**.
34. QUARSHIE P.T., ABDULAI S., FRASER E.D. (Re) assessing Climate-Smart Agriculture practices for sustainable food systems outcomes in sub-Saharan Africa: The case of Bono East Region, Ghana. Geography and Sustainability. **4** (2), 112, **2023**.
35. AJAZ A., BERTHOLD T.A., XUE Q., JAIN S., MASASI B., SADDIQUE Q. Free weather forecast and open-source crop modeling for scientific irrigation scheduling: proof of concept. Irrigation Science. **2023**.
36. HOUNNOU F.E., HOUESSOU A.M., DEDEHOUANOU

H. Farmers' preference and willingness to pay for weather forecast services in Benin (West Africa). Regional Environmental Change. **23** (2), 77, **2023**.
37. SULTANA S. The role of knowledge co-production in climate smart agriculture in Pakistan. UWSpace **2019**.
38. KUVELKAR R., ANJANAPPA J., BHATTACHARYA A. Climate Smart Agriculture to Attain Food Security Based on A Global Outlook. SSRN Electronic Journal. 4384125. **2023**.
39. VERNOOY R., RANA J., OTIENO G., MBOZI H., SHRESTHA P. Farmer-led seed production: Community seed banks enter the national seed market. Seeds. **1** (3), 164, **2022**.
40. QUARSHIE P.T., ABDULAI A.-R., FRASER E. D. Africa's "seed" revolution and value chain constraints to early generation seeds commercialization and adoption in Ghana. Frontiers in Sustainable Food Systems. **5**, 665297, **2021**.
41. LI J., LIU G., CHEN Y., LI R. Study on the influence mechanism of adoption of smart agriculture technology behavior. Scientific Reports. **13** (1), 8554, **2023**.
42. BOJAGO E., ABRHAM Y. Small-scale irrigation (SSI) farming as a climate-smart agriculture (CSA) practice and its influence on livelihood improvement in Offa District, Southern Ethiopia. Journal of Agriculture and Food Research. **12**, 100534, **2023**.
43. QUARSHIE P.T., ABDULAI A.-R., DUNCAN E., KC K.B., ROTH R., SNEYD A., FRASER E.D. Myth or Reality? The Digitalization of Climate-Smart Agriculture (DCSA) Practices in Smallholding Agriculture in the Bono East Region of Ghana. Climate Risk Management. **42**, 100553, **2023**.
44. YIGEZU Y.A., MUGERA A., EL-SHATER T., AW-HASSAN A., PIGGIN C., HADDAD A., KHALIL Y., LOSS S. Enhancing adoption of agricultural technologies requiring high initial investment among smallholders. Technological Forecasting and Social Change. **134**, 199, **2018**.
45. OSUMBA J.J., RECHA J.W., OROMA G.W. Transforming agricultural extension service delivery through innovative bottom–up climate-resilient agribusiness farmer field schools. Sustainability. **13** (7), 3938, **2021**.
46. SARDAR A., KIANI A.K., KUSLU Y. An assessment of willingness for adoption of climate-smart agriculture (Csa) practices through the farmers' adaptive capacity determinants. Yuzuncu Yıl University Journal of Agricultural Sciences. **29** (4), 781, **2019**.
47. KPADONOU R.A.B., OWIYO T., BARBIER B., DENTON F., RUTABINGWA F., KIEMA A. Advancing climate-smart-agriculture in developing drylands: Joint analysis of the adoption of multiple on-farm soil and water conservation technologies in West African Sahel. Land use policy. **61**, 196, **2017**.
48. JABBAR A., LIU W., WANG Y., ZHANG J., WU Q., PENG J. Exploring the Impact of Farmer Field Schools on the Adoption of Sustainable Agricultural Practices and Farm Production: A Case of Pakistani Citrus Growers. Agronomy. **12** (9), 2054, **2022**.
49. ATEKA J., ONONO P., ETYANG M. Does participation in farmer field school extension program improve crop yields? Evidence from smallholder tea production systems in Kenya. International Journal of Agricultural Management and Development. **9** (4), 409, **2019**.
50. COHEN J. Statistical power analysis for the behavioral sciences. Academic press, **2013**.
51. SAWAN Z.M. Cotton production and climatic factors: Studying the nature of its relationship by different statistical methods. Cogent Biology. **3** (1), 1292882, **2017**.
52. FAN Y., WANG C., NAN Z. Determining water use efficiency of wheat and cotton: A meta-regression analysis. Agricultural Water Management. **199**, 48, **2018**.